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Modeling, Simulation, and Analysis: Enabling Early Acquisition Decisions

Fred Hartman—Fred Hartman, Research Staff Member with the Institute for Defense Analyses, Science and Technology Division, has a broad background in Defense-related management and analysis positions in industry and government. Specializing in modeling and simulation (M&S) applications for training, analysis, and acquisition, Mr. Hartman has over 30 years of experience in providing technical management and oversight for Defense and industry programs. He served from 2003 to 2007 in the Office of the Under Secretary of Defense (Personnel and Readiness) as Director, Training Transformation Joint Assessment and Enabling Capability (JAEC), and as Deputy Director, Readiness and Training Policy and Programs (RTPP). In this capacity, he was study director for the Training Transformation Block Assessments and the Training Capabilities Analysis of Alternatives, a major training systems cost-benefit analysis for future M&S applications in joint training. Mr. Hartman currently is supporting the DoD M&S Coordination Office to align corporate and crosscutting capabilities for future development.

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Abstract

The use of systems engineering early in the acquisition cycle is being advocated for programs as a means to add analytic rigor prior to Milestone A. Modeling and simulation (M&S) coupled with early requirements and effectiveness analyses can shape programs and test alternatives prior to costly program commitments. Conceptual modeling and early cost effectiveness analyses are key to revitalizing development planning and early systems engineering, which will enable more-informed decisions by acquisition leadership. Early systems prototyping, coupled with continuous program support and assessment, will enable better acquisition decisions through the series of milestone decisions.

Keywords: modeling, simulation, analysis, early systems engineering, prototyping

Research Issue

In the current DDR&E organization, the Systems Engineering Directorate includes modeling and simulation as part of the Systems Analysis Division. This new organization places powerful assessment capabilities and access to modeling and simulation for systems engineering early in the acquisition program lifecycle.

Background

During the last several decades, we have witnessed incredible progress improving underlying modeling and simulation (M&S) technologies. Dr. Anita Jones (1988) led a Defense Science Board Study (DSB) published in 1988 that recommended improving our simulations to allow for more home station training of commanders and staffs, facilitate the sharing of our simulation data and arrive at more simulation-based training with less developmental redundancy. The 1988 DSB study got to the heart of many of the



fundamental issues in M&S that we are still working to improve today—some two decades later. A few years after the DBS study, the Defense Modeling and Simulation Office (DMSO) was formed, and Dr. Jones took over as the Director, Defense Research and Engineering (DDR&E). During the 1990s, a progressive series of architectures and standards were developed to improve the DoD's ability to form distributed, interoperable simulation environments with reusable scenario data and content. Each of the three M&S communities—Analysis, Training, and Acquisition—kicked off major joint programs during that time. The Acquisition Community formed the Joint Modeling and Simulation System (JMASS) to expand on simulation-based acquisition (SBA)¹ and to leverage simulation capabilities across the acquisition lifecycle. The main thrust of both of these programs was to incorporate models and simulations as very integral components in each phase of the Acquisition process. Although there was not widespread follow-up support, the concepts are still relevant today.

The Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)) is the single focal point for the coordination of all matters related to DoD M&S (USD(AT&L), 2007). The *DoDD 5000.59* provides for the management of M&S via an executive-level DoD M&S Steering Committee, comprised of key agencies in the OSD, the Joint Staff, Services and Combatant Commands. Chair of the M&S SC is delegated to the DDR&E. With the publication of the M&S Steering Committee's *Strategic Vision for Modeling and Simulation* (2007) and *The 2008 Modeling and Simulation Corporate and Crosscutting Business Plan* (DoD, 2009), the DoD M&S community has moved forward on a series of high-level tasks (HLTs) aimed at improving the M&S tools, data, functional representations and enterprise services across the Department. The HLTs are consistent with the five M&S goals contained in the *Strategic Vision*.

For example, the instantiation of Live Virtual and Constructive (LVC) environments for training, experimentation and testing applications show that we can today achieve many of the interoperability goals discussed in the late 1980s. The training community can establish persistent networks dedicated to distributed simulations to link together nodes that are located all over the globe. The technology that has been assembled at the US Joint Forces Command (JFCOM) in their LVC training environment is supported by Joint Training and Experimentation Network (JTEN) and is used by three of our Communities enabled by M&S as well as the Services. The JFCOM training environment has also served the Information Operation (IO) Range to examine cyber network issues for the future. The success of these LVC environments today provides us only a glimpse of the opportunities likely available to enjoy in the net-enabled world of the future. Another area that has seen a tremendous increase in capability is the use and reuse of data for common scenarios and other wide-ranging applications. A number of existing programs in the Services as well as for joint applications have collaborated to solve many of the hard issues that have precluded meaningful data reuse over the last decade. We have learned over time that in M&S, both the user needs and the enabling technologies are continuously evolving. Information technology now supports an environment that allows the creation of more realistic, more capable, and more powerful simulation tools. Significant reductions in program

¹ Overview from Chapter 11.13, *Defense Acquisition Guidebook*: SBA is the robust and interactive use of M&S throughout the product lifecycle. The program manager should employ SBA and M&S during system design, test and evaluation, and modification and upgrade. The program manager should collaborate with operational users and consider industry inputs during SBA/M&S program planning.

development times, lifecycle costs, and improved systems performance can be realized through use of M&S in acquisition.

Acquisition Reform

It is widely perceived that there are problems with the DoD acquisition process. Several of the common complaints from the user communities are as follows:

- Too slow,
- Requires significant labor investments just to satisfy and document the process,
- Capabilities frequently reach concept decision and enter Milestone A without sufficient concept refinement and contact with the users, and
- Too many requests from senior management for more rigorous analysis to drive decisions for program start up and/or no go early in the process.

The acquisition reform goals and policies of the Obama Administration outline actions that impact government procurement, acquisition programs and contractors in a wide variety of areas. The convergence of new administration priorities, burgeoning costs, and outdated procurement processes has prompted major contracting and policy initiatives designed to:

- Develop more agile acquisition processes to increase the speed of technology deployment,
- Increase transparency of the acquisition process,
- Institute stricter risk and performance parameters, and
- Reduce costs through cuts in contractor spending and use of “high-risk” contract types.

This paper proposes that M&S can assist the USD(AT&L) in meeting the new administrations’ acquisition reform initiatives. Key to reform is the ability to both compress timelines and add more analytic rigor to the acquisition process through the use of modeling and simulation. Especially in the early stages of the acquisition process, the use of M&S for rapid prototyping and to support the analyses stages prior to Milestone A is useful to influence the early concepts, design and recommendations for major systems procurements. Although extremely important in the early stages of acquisition, the use of M&S applications at every stage of the process provides efficiencies and improvements in a wide variety of uses from requirements to technical aspects of design and development to sustainment of a given system. M&S is more than a single tool or set of tools used at critical points in the process; it is rather a way of doing business that impacts every aspect of a system’s lifecycle. In July 2009, the DDR&E introduced four Imperatives to focus the organization in support of the immediate and future needs of the Department of Defense: 1) accelerate delivery of technical capabilities to win the current fight; 2) prepare for an uncertain future; 3) reduce the cost, acquisition time and risk of our major defense acquisition programs; and 4) develop world class science, technology, engineering, and mathematics capabilities for the DoD and the nation. The use of M&S is a clearly an enabler to achieve Imperative 3 above.

Simulation-Based Acquisition (SBA)

The concepts of the SBA program formed a decade ago are still viable—but largely unachieved today. The SBA vision encompasses an acquisition process in which the DoD



and industry partners are enabled by the robust, collaborative use of simulation technology integrated across all acquisition phases and programs. The goals of SBA are very consistent with the current administration's acquisition reform policy initiatives:

- Reduce time, resources, and risk associated with the entire acquisition process;
- Increase the quality, military worth and supportability of fielded systems;
- Reduce total ownership costs throughout the system lifecycle; and
- Enable integrated product and process development across the entire acquisition lifecycle.

In keeping with the SBA vision and goals, the Department can provide a systems engineering environment that emphasizes M&S as a primary analysis tool and fosters the use and reuse of data and M&S content across programs and phases. It is envisioned that use of models can refine the needs and provide the underpinning for more rigorous analyses prior to Milestone A, while transitioning critical content to guide systems design and later development and production processes. As far back as 1997, Dr. Pat Sanders, the then-Director, Test, System Engineering and Evaluation, OUSD (A&T), was writing magazine articles on SBA as an effective, affordable mechanism for fielding complex technologies. Even almost 13 years ago, it was believed that the extensive use of constructive models for system-of-systems evaluations would provide significant benefits—particularly as they would enhance virtual prototypes that could be operated on future synthetic battlefields. One can believe the future as regards these simulation environments is very close at hand today.

Early Prototyping

From the early requirements and conceptualization stages, the use of M&S and in particular system prototyping provides a powerful analytic capability to meet user needs. It has been argued that prototypes are platforms for productive participation, as well as for perfecting products and performance (Schrage, 2010). The power of producing systems prototypes early in the process serves as a way to iterate with the end user to arrive at better systems and solutions for the operational needs. The more obvious use of prototypes is to guide the engineering analysis in the development planning stage of the acquisition. Any number of firms can be found through the internet proposing services to industry in the area of model making and prototyping. Many of these firms are highly successful, providing rapid prototyping services that encompass proof of concept and proof of design with functional working simulations and models. The use of prototyping can encompass constructive simulations, virtual environments or physical mock ups of the end system or product. With the use of such tools as 3D visualization, one can progress to “model making” to influence the construct of actual 3D models. The area of rapid prototyping uses state-of-the-art CAD/CAM (computer-aided design and computer-aided machining or modeling) techniques. Significant advances in the area of M&S make it now more important than ever that we incorporate oversight policies and directives to include contracting language that requires the use of simulations, models and prototypes in all phases of the acquisition process.

Research Result

M&S can provide a combination of live, virtual and constructive acquisition environments to impact policies and acquisition decisions early in program development and throughout the acquisition process to facilitate efficiencies and avoid costly program errors.



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2003 - 2010 Sponsored Research Topics

Acquisition Management

- Acquiring Combat Capability via Public-Private Partnerships (PPPs)
- BCA: Contractor vs. Organic Growth
- Defense Industry Consolidation
- EU-US Defense Industrial Relationships
- Knowledge Value Added (KVA) + Real Options (RO) Applied to Shipyard Planning Processes
- Managing the Services Supply Chain
- MOSA Contracting Implications
- Portfolio Optimization via KVA + RO
- Private Military Sector
- Software Requirements for OA
- Spiral Development
- Strategy for Defense Acquisition Research
- The Software, Hardware Asset Reuse Enterprise (SHARE) repository

Contract Management

- Commodity Sourcing Strategies
- Contracting Government Procurement Functions
- Contractors in 21st-century Combat Zone
- Joint Contingency Contracting
- Model for Optimizing Contingency Contracting, Planning and Execution
- Navy Contract Writing Guide
- Past Performance in Source Selection
- Strategic Contingency Contracting
- Transforming DoD Contract Closeout
- USAF Energy Savings Performance Contracts
- USAF IT Commodity Council
- USMC Contingency Contracting

Financial Management

- Acquisitions via Leasing: MPS case
- Budget Scoring
- Budgeting for Capabilities-based Planning



- Capital Budgeting for the DoD
- Energy Saving Contracts/DoD Mobile Assets
- Financing DoD Budget via PPPs
- Lessons from Private Sector Capital Budgeting for DoD Acquisition Budgeting Reform
- PPPs and Government Financing
- ROI of Information Warfare Systems
- Special Termination Liability in MDAPs
- Strategic Sourcing
- Transaction Cost Economics (TCE) to Improve Cost Estimates

Human Resources

- Indefinite Reenlistment
- Individual Augmentation
- Learning Management Systems
- Moral Conduct Waivers and First-term Attrition
- Retention
- The Navy's Selective Reenlistment Bonus (SRB) Management System
- Tuition Assistance

Logistics Management

- Analysis of LAV Depot Maintenance
- Army LOG MOD
- ASDS Product Support Analysis
- Cold-chain Logistics
- Contractors Supporting Military Operations
- Diffusion/Variability on Vendor Performance Evaluation
- Evolutionary Acquisition
- Lean Six Sigma to Reduce Costs and Improve Readiness
- Naval Aviation Maintenance and Process Improvement (2)
- Optimizing CIWS Lifecycle Support (LCS)
- Outsourcing the Pearl Harbor MK-48 Intermediate Maintenance Activity
- Pallet Management System
- PBL (4)
- Privatization-NOSL/NAWCI
- RFID (6)



- Risk Analysis for Performance-based Logistics
- R-TOC AEGIS Microwave Power Tubes
- Sense-and-Respond Logistics Network
- Strategic Sourcing

Program Management

- Building Collaborative Capacity
- Business Process Reengineering (BPR) for LCS Mission Module Acquisition
- Collaborative IT Tools Leveraging Competence
- Contractor vs. Organic Support
- Knowledge, Responsibilities and Decision Rights in MDAPs
- KVA Applied to AEGIS and SSDS
- Managing the Service Supply Chain
- Measuring Uncertainty in Earned Value
- Organizational Modeling and Simulation
- Public-Private Partnership
- Terminating Your Own Program
- Utilizing Collaborative and Three-dimensional Imaging Technology

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Modeling, Simulation, & Analysis: Enabling Early Acquisition Decisions

**Panel – 3
May 12, 2010
7th Annual Acquisition
Research Symposium**

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Bottom Line Up Front



- We claim M&S provides both cost efficiencies and enhanced capabilities
- **USD (AT&L) has DoD lead for M&S**
- M&S has made significant advances in interoperability and reuse but is ...
- Still not an integral part of AT&L portfolio
- Acquisition community can leverage the enabling benefits of M&S in every stage of the systems process

M&S in AT&L – Short History



- 1988 - DSB led by Dr. Anita Jones
 - Computer applications for training
 - Advocated interoperable and reusable distributed training environments
- 1990s - USD (AT&L) becomes responsible agent and DMSO formed under DDR&E
- 2000s Simulation Based Acquisition (SBA) incorporated in Def Acq Guidebook

“We must make far greater use of M&S to cut costs, as well as shorten development cycles ...”

Hon. Jacques S. Gansler, USD(AT&L) Sep 22, 1999

M&S in Industry – Short History

- **Aircraft design and development**
 - Boeing used computer models to develop airframes for 767 and 777
 - Boeing could test far more designs on the computer than it ever could with wind tunnels
- **Auto industry now uses computers for model based designs – target to reduce cost (\$4B+) & time (by 50%) to introduce new models**
 - Virtual models avoid costly and time consuming clay physical “models”
- **Architects and Engineers have used CAD / CAM software for more than 2 decades**
- **Daimler Chrysler and Boeing claim M&S benefits in design, market forecasting, & training**

Streamlining Acquisition



- **Some perceptions on Defense acquisition**
 - Slow, need to shorten development cycles
 - Significant labor requirements to satisfy the “process”
 - Services report they are spending too much time and money producing acquisition documents which no one reads
 - Capabilities frequently reach concept decision and enter into Milestone A or A/B without sufficient “concept refinement”
 - Senior managers request need for analysis driving decisions for program start up or go – no go earlier in concept process
- **SBA Goals**
 - Reduce time, resources, and risk associated with entire acquisition process
 - Increase quality, military worth, and supportability
 - Reduce ownership costs over system life
 - Enable integrated product development

Target Applications for M&S



- **Requirements refinement and management**
 - Models / prototypes can pin down and refine system requirements early in the product life cycle
 - Simulations can mimic performance characteristics of hardware as well as software components
 - Early prototypes can carry forward into design development and test phases
- **Project Management**
 - Simulation can enable more accurate predictions of cost and schedule
 - M&S is inherently more accurate than cost models based on historic data since it accommodates specific process dynamics
- **Process Improvement**
 - Simulation supports all levels of software Capability Maturity Model
 - Forces manager to address metrics and process behavior

Target Applications for M&S (2)

- **Systems Design and COTS Integration**
 - Many weapons systems require very complex software systems to perform effectively
 - Building software systems usually begins with addressing system architecture
 - Models allow some optimization of competing attributes (reliability, supportability, maintainability, reusability, survivability, mobility, etc) and their interdependencies
- **Risk Management**
 - Simulation can identify project risks and help design less risk-prone strategies
 - Quantitatively predict consequences of alternate decisions
- **Acquisition Management**
 - Simulation can help validate contractors estimates of costs and schedules and provide insights into system performance

State of Simulation Technology



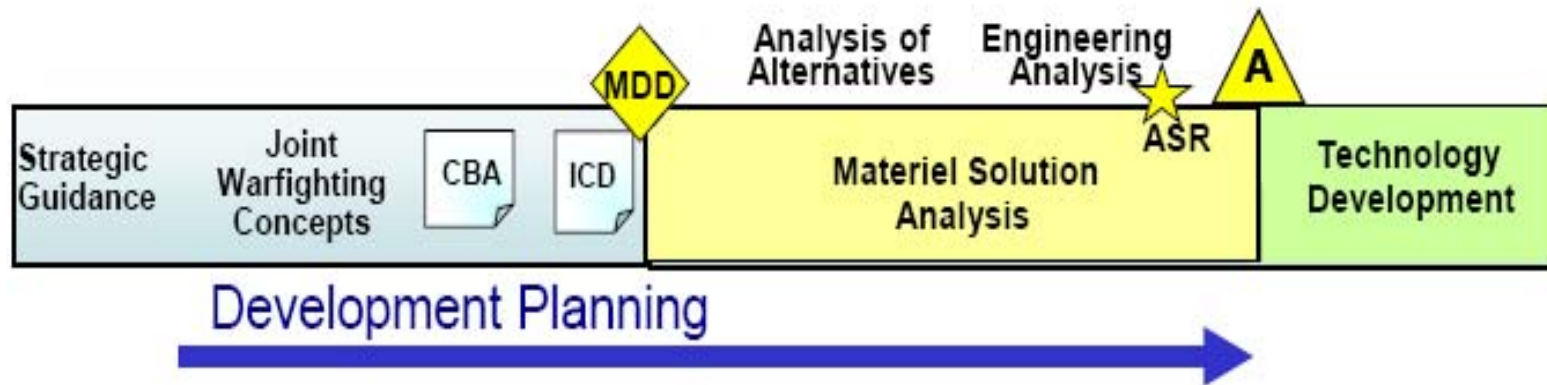
- **Evolution of model building environment**
 - In the past programmers developed models by textual coding
 - Graphical simulation tools are now available
 - Rapid model development through drag & drop icons
 - Graphic element linking
 - Syntactic constraints on linking elements
- **Network-based simulation tools**
 - Facilitates rapid development of large detailed models
 - Supports up-front systems engineering
 - Requires significantly less training of the workforce
 - Focus more on the model's semantic validity
 - Additional incremental costs may be incurred for reuse

Future Environment



- **Tight budget, short timelines, rapidly changing events, increased uncertainty**
- **Requirements for interoperable systems and tools for planning, training, and testing applications**
- **Net-centric operations with joint, inter-agency and multi-national information sharing**
- **Cross domain information sharing with increased needs for security assurance and cyber protections**

Pre-Milestone A



- Systems Engineering & Systems Analysis sand box
- Target rich environment for early M&S applications
- Build systems prototypes early and extend into model based design and model based development

RFP = Request for Prototype?

Summary



-
- **M&S can be used as a key enabler to meet goals of acquisition reform**
 - **Combination of constructive simulations and virtual simulators can be introduced early to refine user needs and technology opportunities**
 - **Is the acquisition community ready now to expand use of M&S?**

Questions?